TITLE: Imaging the Moon's core with seismology (Invited)

CURRENT SECTION/FOCUS GROUP: Seismology (S)
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Constraining the structure of the lunar core is necessary to improve our understanding of the present-day thermal structure of the interior and the history of a lunar dynamo, as well as the origin and thermal and compositional evolution of the Moon. We analyze Apollo deep moonquake seismograms using terrestrial array processing methods to search for the presence of reflected and converted energy from the lunar core. Although moonquake fault parameters are not constrained, we first explore a suite of theoretical focal spheres to verify that fault planes exist that can produce favorable core reflection amplitudes relative to direct up-going energy at the Apollo stations. Beginning with stacks of event seismograms from the known distribution of deep moonquake clusters, we apply a polarization filter to account for the effects of seismic scattering that (a) partitions energy away from expected components of ground motion, and (b) obscures all but the main P- and S-wave arrivals. The filtered traces are then shifted to the predicted arrival time of a core phase (e.g. PcP) and stacked to enhance subtle arrivals associated with the Moon's core. This combination of filtering and array processing is well suited for detecting deep lunar seismic reflections, since we do not expect scattered wave energy from near surface (or deeper) structure recorded at varying epicentral distances and stations from varying moonquakes at varying depths to stack coherently. Our results indicate the presence of a solid inner and fluid outer core, overlain by a partial-melt-containing boundary layer (Table 1). These layers are consistently observed among stacks from four classes of reflections: P-to-P, S-to-P, P-to-S, and S-to-S, and are consistent with current indirect geophysical estimates of core and deep mantle properties, including mass, moment of inertia, lunar laser ranging, and electromagnetic induction. Future refinements are expected following the successful launch of the GRAIL lunar orbiter and SELENE 2 lunar lander missions.

depth (km)	vp	vs	ρ (g/cm3)
0.0	1.0	0.5	2.6
1.0	1.0	0.5	2.6
1.0	3.2	1.8	2.7
15.0	3.2	1.8	2.7
15.0	5.5	3.2	2.8

40.0	5.5	3.2	2.8
40.0	7.7	4.4	3.3
238.0	7.7	4.4	3.3
238.0	7.8	4.4	3.4
488.0	7.8	4.4	3.4
488.0	7.6	4.4	3.4
738.0	7.6	4.4	3.4
738.0	8.5	4.5	3.4
1257.1	8.5	4.5	3.4
1257.1	7.5	3.2	3.4
1407.1	7.5	3.2	3.4
1407.1	4.1	0.0	5.1
1497.1	4.1	0.0	5.1
1497.1	4.3	2.3	8.0
1737.1	4.3	2.3	8.0